

Communications of the Association for Information Systems

Volume 43

Article 40

12-2018

Learning from the History of Business Intelligence and Analytics Research at HICSS: A Semantic Text-mining Approach

Olivera Marjanovic

University of Technology Sydney, olivera.marjanovic@uts.edu.au

Barbara Dinter

Chemnitz University of Technology

Follow this and additional works at: <https://aisel.aisnet.org/cais>

Recommended Citation

Marjanovic, Olivera and Dinter, Barbara (2018) "Learning from the History of Business Intelligence and Analytics Research at HICSS: A Semantic Text-mining Approach," *Communications of the Association for Information Systems*: Vol. 43 , Article 40.

DOI: 10.17705/1CAIS.04340

Available at: <https://aisel.aisnet.org/cais/vol43/iss1/40>

This material is brought to you by the AIS Journals at AIS Electronic Library (AISeL). It has been accepted for inclusion in Communications of the Association for Information Systems by an authorized administrator of AIS Electronic Library (AISeL). For more information, please contact elibrary@aisnet.org.



Learning from the History of Business Intelligence and Analytics Research at HICSS: A Semantic Text-mining Approach

Olivera Marjanovic

University of Technology Sydney
Australia
olivera.marjanovic@uts.edu.au

Barbara Dinter

Chemnitz University of Technology
Germany
barbara.dinter@wirtschaft.tu-chemnitz.de

Abstract:

Although multidisciplinary by nature, the Hawaii International Conference on Systems Sciences (HICSS) has established itself as the leading international conference in business intelligence (BI), business analytics (BA) and, more recently, big data research. Given a large number of academic and industry conferences in these areas, it is worth reflecting on and learning from the long tradition of BI and BA research at HICSS. In this paper, we analyze the 28-year history of HICSS' longest-running minitrack on BI and BA in order to identify its main research themes and reflect on their evolution over time. Our insights provide research grounding for the current thinking about the big data phenomenon, which, contrary to many statements, is not new. We also illustrate a practical method of combining a semantic text-mining tool (Leximancer) and collaborative sensemaking. Reflecting on the method, we argue that technology itself—regardless of how sophisticated it might be—does not generate meaningful insights. Rather, we argue that domain experts co-construct these insights through an iterative collaborative sensemaking process in a given context, an important point that other researchers interested in semantic text-mining tools should consider.

Keywords: Business Intelligence, Business Analytics, Big Data, Semantic Text Mining, Content Analysis, Leximancer.

This manuscript underwent peer review. It was received 05/01/2017 and was with the authors for 4 months for 2 revisions. K.D. Joshi served as Associate Editor.

1 Introduction

Fueled by an unprecedented interest in big data (Chen, Chiang, & Storey, 2012; Watson, 2014), the so-called “data analytics” revolution is well under way (Mayhew, Saleh, & Williams, 2016). Yet, despite the enormous amounts of data that companies now collect, many still struggle to translate it into actionable and value-adding information (Mayhew, Saleh, & Williams, 2016; Veeramachaneni, 2016). In turn, one can expect this challenge to draw even more attention to data and analytics as industry practitioners and researchers continue looking for possible solutions.

The unprecedented interest in this discipline has also resulted in an ongoing “conceptual confusion” in which many scholars and practitioners often misinterpret its foundational concepts or interpret them in mutually inconsistent ways. For example, some scholars and practitioners use the term business intelligence (BI) as a synonym for business analytics (BA) (Gupta, Goul, & Dinter, 2015). Other industry and academic circles use BI to describe reporting tools or technical infrastructure and BA to describe more advanced analytical tools, such as predictive analytics or data mining (see Gupta et al., 2015; Watson, 2014).

While definitions will continue to evolve, in this paper, we adopt the “umbrella” term of business intelligence and analytics (BI&A) to promote a holistic view of analytics. Thus, following Chen et al. (2012), we use the all-encompassing term BI&A to describe a whole spectrum of BI and BA applications, which includes technical infrastructures, different types of analytics (descriptive, prescriptive and predictive), and corresponding organizational practices such as data governance. We also emphasize decision making in a context that a business problem or opportunity drives. As such, our view of BI&A differs from various data science and information technology (IT) approaches that emphasize de-contextualized data and/or analytics tools.

The growing interest in BI&A has also resulted in a large number of related conferences and dedicated minitracks/tracks across diverse academic disciplines such as information systems, computer science, information technology, business, management, political sciences, and even journalism and the natural sciences. Among them, the Hawaii International Conference on Systems Sciences (HICSS) has remained at forefront of BI&A research for many years (Chen et al., 2012) due to the conference’s long-term goal to always include cutting-edge research as opposed to, for example, replications or extensions of well-established research streams. Therefore, we argue that we can learn much from the history of related work at HICSS and, thus, provide our multidisciplinary community some valuable insights about the origins and evolution of BI, BA, and, more recently, big data research.

With this goal in mind, we turn our attention to a specific HICSS minitrack with the longest history of BI&A-related research currently called organizational issues of business intelligence, business analytics, and big data. We trace the origins of this minitrack back to HICSS-23 and the executive information systems minitrack that Hugh Watson and Joseph Walls started in 1990. One can attribute the continuity and longevity of this particular minitrack to its founder and long-serving co-chair Hugh Watson.

We analyzed the 28-year long history of this particular BI&A minitrack in order to identify its main research themes and reflect on their evolution over time. Our insights provide research grounding for current thinking about the big data phenomenon, which, contrary to many statements, is not new or even recent. We also illustrate a practical method of combining a semantic text-mining tool (Leximancer) with collaborative sensemaking. Reflecting on the method, we argue that technology itself—regardless of how sophisticated it might be—does not generate meaningful insights. Rather, we argue that domain experts co-construct these insights through an iterative collaborative sensemaking process in a given context, an important point that other researchers interested in semantic text-mining tools (such as Leximancer) should consider in their own contexts and research domains.

The paper proceeds as follows. In Section 2, we briefly review the historical origins of BI&A research. In Section 3, we describe our research context. In Section 4, we provide the necessary foundations of lexical analysis with the Leximancer tool. In Section 5, we describe our research method. In Section 6, we present our findings. In Section 7, we reflect on the research method and its outcomes. Finally, in Section 8, we describe the main conclusions and present some ideas for future work beyond HICSS.

2 Origins of BI&A Research

One can trace the origins of current BI&A research back to early days of computer-based decision support systems (DSS) in the 1960s (Watson, 2009). For example, looking at the history of DSS, Power (2007) identifies five broad categories and shows how data warehousing (DW), executive information systems (EIS), and BI evolved in the late 1980s and early 1990s. Also reflecting on the history of DSS, Watson and Marjanovic (2014) see big data as the fourth generation of data management after traditional DSS (the first), enterprise data warehouses (the second), and real-time DW (the third). By revisiting one of the most influential DSS frameworks (i.e., Ralph Sprague's framework for DSS development), Watson (2018) demonstrates that Sprague's core conceptualizations still apply to today's contemporary BI&A environments even though new types of data, users, technologies, models and applications have emerged. Arnott and Pervan (2005) and Hosack, Hall, Paradice, and Courtney (2012) also comprehensively overview DSS. While we acknowledge BI&A's origins in DSS, we also consider it a separate research stream from more traditional DSS.

Turning our attention to BI&A research, we observe that numerous contributions provide the so-called "meta perspective" on BI and BA topics mainly in the form of literature reviews, research agendas, and conceptualizations of the disciplines. For example, based on their own extensive literature reviews, several authors focus on understanding, conceptualizing, and/or systematizing BI (e.g., Baars et al., 2014; Chee et al., 2009; Jourdan, Kelly Rainer, & Marshall, 2008; Pirttimäki, 2007; Shollo & Kautz, 2010). Surprisingly few contributions offer a comprehensive research agenda for BI. Instead, they focus on selected, more-specific research challenges, such as those that Baars et al. (2014), Goul (2010), Negash (2004), and Watson (2009) discuss. Looking across these exemplary papers, we observe that BI-related reviews tend to focus on the past and describe BI as an evolutionary theme.

In contrast, the review papers about BA and big data (analytics) tend to focus on the future. They have also appeared more recently. Due to the emerging nature of big data research, few contributions provide extensively review the literature on and/or conceptualize big data. Instead, the existing review papers focus on setting future research agendas and presenting the discipline as revolutionary. For example, Chen et al. (2012) review ten years of BI&A-related research and propose the well-known BI&A research framework. Similarly, Abbasi, Sarker, and Chiang (2016) provide a comprehensive research agenda for big data according to the big data information value chain. Guided by a big data analytics framework, Phillips-Wren, Iyer, Kulkarni, and Ariyachandra (2015) discuss future research opportunities in this discipline. Many other prominent papers address research challenges in analytics and/or big data as well (e.g., Chen & Zhang, 2014; Hashem et al., 2015; Kambatla, Kollias, Kumar, & Grama, 2014; Watson, 2014).

With this brief analysis of the historical origins of the BI&A discipline, we set a wider background for our work and can position related research at HICSS in its historical context. Against this background, in Section 3, we turn our attention to BI&A-related research at HICSS.

3 Research Context: BI&A-related Research at HICSS

Recently, HICSS has seen a significant increase of minitracks and tracks that investigate different aspects of BI, BA, and big data based on their titles. For example, HICSS-50, held in 2017, had eight workshops and 15 minitracks all related to big data and analytics. Their respective content and the main emphasis illustrate the point we make in Section 1 about how many scholars and practitioners often misinterpret the discipline's foundational concepts or interpret them in mutually inconsistent ways. We argue that scholars ought to investigate BI&A from many different disciplinary perspectives due to its complex multi-faceted nature. At the same time, the existing mutually inconsistent interpretations of the foundation terms and concepts will continue to make the much-needed cross-disciplinary dialogue difficult. By analyzing the longest running BI&A minitrack, we contribute to setting up the necessary foundations for such a dialogue in and beyond HICSS.

Furthermore, we also observe that one can trace the history of BI&A research at HICSS to several minitracks. Using the analytical tool that the HICSS-50 website (hicss.hawaii.edu) provides, we performed a simple search using the keywords "data warehousing", "business intelligence", "business analytics" and "big data". Figure 1 depicts the resulting number of papers presented at HICSS over time.

Although useful, this simple visualization does not tell a complete story of BI&A- and big data-related research at HICSS. First, it does not trace its history over time and show, for example, how BI research evolved into BA research. Second, it does not consider the origins of BI&A research (e.g., in DW or earlier

in EIS). New researchers who may not be familiar with the whole history of BI&A research (see Section 2) will likely remain unaware of these origins.



Figure 1. History of BI&A and Big Data Papers Presented at HICSS since 1995

Considering these issues, we focused on a particular BI&A minitrack at HICSS currently called organizational aspects of business intelligence, business analytics, and big data. We traced its 28-years long history (which has seen it adopt various names) back to HICSS-23 (see Table 1).

Table 1. History of the Minitrack's Alternative Titles and Respective Co-chairs

Year	Name	Chairs
1990-1996	Executive information systems	Hugh Watson, Joseph Walls
1997-1998	Data warehouses and information delivery systems	Hugh Watson, Joseph Walls
1999-2003	Data warehousing	Barbara Wixom, Paul Gray, Hugh Watson
2004-2008	Data warehousing and business intelligence	Barbara Wixom, Hugh Watson
2009	Data warehousing, business intelligence and information logistics	Hugh Watson, Robert Winter, Barbara Wixom
2010	Data warehousing, business intelligence and information logistics	Robert Winter, Hugh Watson, Barbara Wixom
2011	Business intelligence, data warehousing and process analytics	Robert Winter, Olivera Marjanovic, Barbara Wixom
2012	Business analytics, business intelligence and data warehousing	Robert Winter, Olivera Marjanovic, Barbara Wixom
2013	Business analytics, business intelligence and big data	Robert Winter, Olivera Marjanovic, Barbara Wixom
2014	Business analytics, business intelligence and big data	Olivera Marjanovic, Thilini Ariyachandra, Barbara Dinter
2015	Organizational issues for business intelligence, business analytics, and big data	Olivera Marjanovic, Thilini Ariyachandra, Barbara Dinter
2016-2017	Organizational issues of business intelligence, business analytics, and big data	Olivera Marjanovic, Barbara Dinter, Thilini Ariyachandra

All these years, the minitrack has remained in the same organizational systems and technology track. Also, the minitrack's founder Hugh Watson co-chaired it for many years. Being also the main track chair, Watson has contributed to the ongoing evolution of the minitrack over its entire history. Therefore, despite the minitrack's different names and foci, one can justifiably claim it has continued over time. In Section 4, we briefly introduce lexical analysis so readers can better understand our data-analysis method and its results.

4 Foundations of Lexical Analysis with Leximancer

Leximancer, an advanced text-mining software tool, analyzes the frequency of co-occurrences of words in blocks of text to produce a set of inter-related maps of derived semantic concepts and themes (Leximancer, 2010). At its core, the software applies complex statistical algorithms to very large volumes of unstructured textual data to identify semantic concepts in data. Based on their derived semantic proximity, the tool groups these concepts into clusters known as themes. It then visualizes the resulting themes in “concept maps” with colored circles. The relative size and brightness of these circles correspond to the occurrences of identified themes in texts (Leximancer, 2010). Leximancer uses the resulting concept maps to establish the relational strength between different concepts that researchers can use to interpret the strength of associations. Researchers have extensively evaluated the software for stability, reproducibility, and the correlative validity of its underlying statistical algorithms (Smith & Humphreys, 2006).

In addition to visualizing concepts and themes in a user-friendly way, Leximancer also generates a thesaurus of identified concepts and their derived “definitions”. Also, for each identified concept or theme, the software enables the user to drill down to the underlying paragraphs/sentences of raw (original) text from which it derived the concept/theme in order to confirm or refine its meaning.

Numerous researchers in diverse research disciplines, such as accounting (Crofts & Bisman, 2010), sports management (Anagnostopoulos & Bason, 2015), cross-cultural psychology (Cretchley, Rooney & Gallois, 2010), business ethics (Lock & Seele, 2015) and design science (Indulska & Recker, 2008), have used Leximancer for more than a decade. According to Indulska, Hovorka, and Recker (2012), many researchers who perform text mining-based content analysis prefer Leximancer over other tools that provide similar functionality.

Furthermore, Leximancer has enabled researchers to analyze common themes across different journals (e.g., in IS: Aryal, Gallivan, & Tao, 2015; Carter, Petter, & Randolph, 2015; Indulska et al., 2012). Similar to our research, researchers have also used Leximancer to analyze histories of research publications in a single journal or a conference; for example, Cretchley et al. (2010) analyzed the themes and concepts in the *Journal of Cross-Cultural Psychology* over a 40-year period, Anagnostopoulos and Bason (2015) the *Sports Management International Journal* over a 10-year period, and Young, Wilkinson, and Smith (2015) the *Journal of Business-to-Business Marketing* over a 22-year period. However, to the best of our knowledge, researchers have yet to use this type of content analysis to analyze histories of BI&A-related conference (mini)tracks or journals, which we find somewhat surprising given the fact that one can classify an advanced text-mining tool such as Leximancer as a BI&A tool. This particular observation led to the main idea for our research. In Section 5, we introduce the research method we adopted.

5 Research Method

5.1 Data Collection

In this study, we collected all papers published between 1990 and 2017 in the HICSS minitrack currently named organizational aspects of business intelligence, business analytics, and big data. We sourced all papers from IEEE Xplore and the HICSS websites. Some of the earlier proceedings (e.g., 1994) did not include published introductions to minitracks. In those cases, we cross-referenced the minitrack’s list of papers (provided by IEEE Xplore) with other databases such as Google Scholar to confirm the completeness of our data set.

Our resulting data set included 144 peer-reviewed papers. We excluded minitrack introductions and several panels held in the early years of this minitrack for two reasons. First, they did not all appear in the proceedings. Second, even when they did, they did not go through a full referee process.

All papers were in .pdf format; as such, Leximancer could easily “read” them. We then divided them into four groups that corresponded to the minitrack’s different historical phases. To determine these phases, we considered the minitrack’s changing titles. We also observed several shifts in its main focus. As Table 2 shows, the first group included papers from 1990 to 1996 that clearly focused on EIS. The second group included papers from 1997 to 2003, many of which newly focused on DW. The third group included papers from 2004 to 2011. Although the topic of DW remained in the title for several more years, the minitrack began to include BI and, for two years, information logistics. Finally, the fourth group included

papers from 2012 to 2017. This latter period demonstrates the latest shift to BA (since 2012) and the most recent inclusion of big data from 2013 until today.

Table 2. Data Collection and Grouping of Papers

Group	Period	Focus	No. of papers
1	1990-1996	Executive information systems (EIS)	38
2	1997-2003	Data warehousing (DW)	29
3	2004-2011	DW extended with business intelligence (BI)	36
4	2012-2017	BI extended with business analytics (BA) (from 2012) and big data (from 2013)	41
Total:			144

5.2 Descriptive and Lexical Data Analysis

Using the resulting data set of 144 papers, we performed two types of analysis: descriptive and lexical. We performed the descriptive analysis to understand the widening global context of BI&A research as papers in this minitrack have discussed over time and its impact beyond HICSS through citation analysis. We performed the lexical analysis to understand the changing nature of research that papers in this minitrack have discussed throughout its 28-year history.

We performed the lexical analysis as follows: we uploaded all collected research papers (in .pdf form) into Leximancer and divided them into four groups. Compared to other studies that use abstracts for Leximancer analysis, we decided to use complete (full) papers to increase the richness of our data set.

We guided the actual text-mining process, which included several reflective phases of collaborative sensemaking. In the first phase, we ran an initial overall analysis of all papers in each individual group to identify the most frequently occurring concepts while excluding the common stop words such as “and” and “or”. We created concept maps for each group to identify and remove additional stop words such as “pp.”, “HICSS”, and “proceedings” since they appeared in the headers/footers of all papers that IEEE Xplore published. We then analyzed all resulting concepts to determine their relevance and semantic meaning by examining the corresponding thesaurus (which Leximancer also compiled). Consequently, we merged some concepts into more meaningful combined concepts (e.g., we merged “user” and “users” into one concept). We also examined the emerging concepts by drilling down to the underlying text from individual papers to better comprehend their meaning. For example, we established the concept that Leximancer named “organization” to mean “business” as in “business perspective”. To sustain the reliability of the results in and across concept maps, we conducted the same type of analysis across all groups of papers. For example, we omitted the same stop words from each concept map and analyzed them in parallel across all four groups.

In the next phase, we analyzed the outcomes of the first phase independently and documented their own individual insights. Then, in the third phase, we discussed and combined these individual insights through an ongoing iterative process that we can best describe as collaborative sensemaking by domain experts in a given context. This context comprised this minitrack’s whole history and wider history of BI&A research and industry trends over time. This process led to an agreed interpretation (i.e., shared meaning) of Leximancer-produced concepts and themes that considered their historical context. Subsequently, we performed more reflective cycles—from Leximancer-generated concepts and themes to individual insights to shared meaning—until we generated no new concepts and themes.

6 Research Insights

6.1 Descriptive Analysis

Figure 2 depicts the total number of accepted papers per year. It also illustrates how the number of papers for the three most active countries¹ (US, Australia, and Germany) has evolved over time.

¹ We determined a paper’s “country” according to authors’ affiliations as they appeared in the proceedings and not their nationality or some other metric.

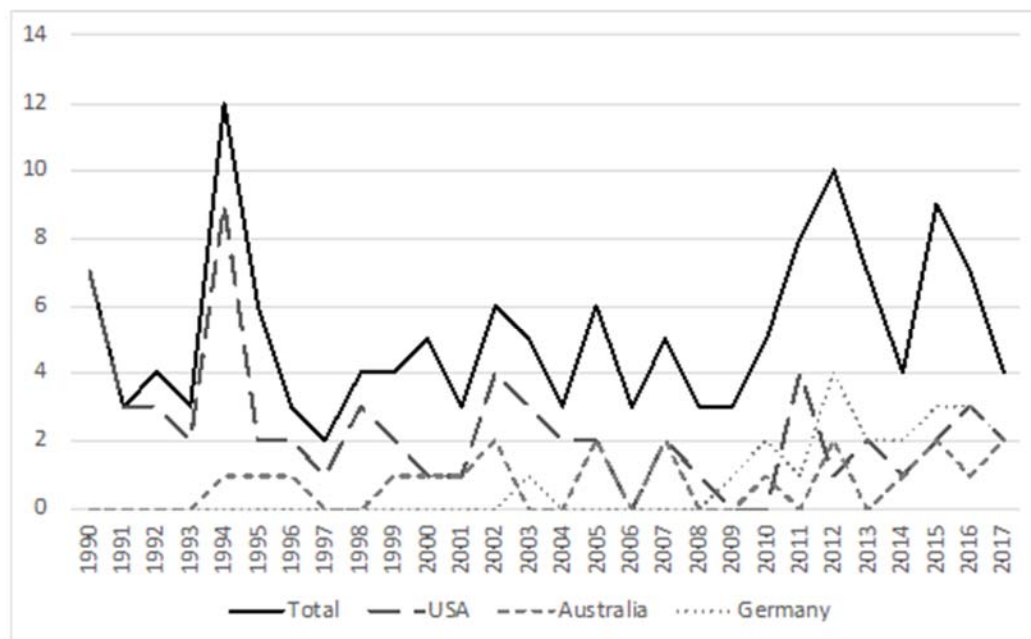


Figure 2. Number of Papers per Year

While the minitrack predominantly featured papers from US authors in its beginning, it has become more international over time. We can say the same about the co-chairs who, since 2011, have come from three geographic regions (USA, Europe, and Australasia). Their collective efforts and influence have contributed to this firmly establishing this minitrack as truly international. Furthermore, international research teams have presented 14 papers and practitioners have presented five papers. Figure 3 visualizes the submissions per country in more detail.

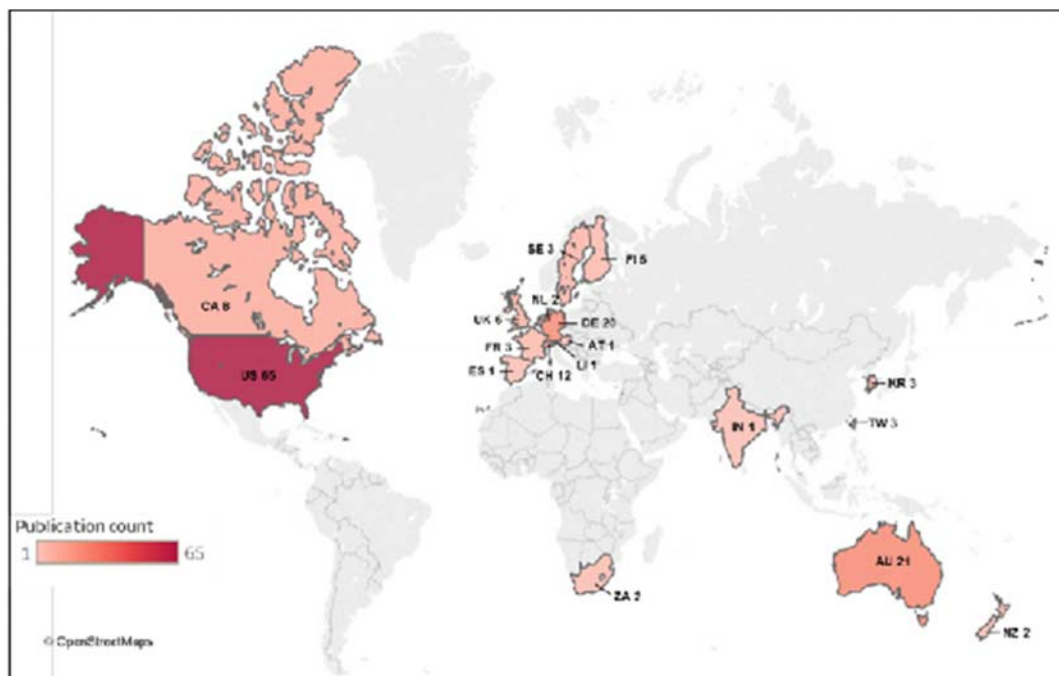


Figure 3. Number of Papers per Country

We also examined the top contributors to the minitrack in terms of authors with most papers, institutions with most papers, and the papers that have received the most citations. For the latter, we used the Google Scholar citation count. Table 3 includes the results for the top three in each category. The right column includes the number of papers for most active authors, number of authors for most active institutions, and number of citations for papers with the most citations.

Table 3. Top Authors, Affiliations, and Citations

Most active authors		
1	R. Winter, University of St. Gallen	8
2	O. Marjanovic, University of Sydney	5
3	M. K. Brohman, Queen's University; S. A. Carlsson, Lund University; M. Goul, Arizona State University; D. Leidner, INSEAD; C. Milligan, Sun Microsystems; G. Shanks, University of Melbourne; J. G. Walls, and California State University; F. Wortmann, University of St. Gallen	4
Most active institutions		
1	University of St. Gallen, Switzerland	12
2	Arizona State University, USA	8
3	University of Sydney, Australia	6
Most cited papers		
1	Alavi, M., & Leidner, D. (1999): Knowledge management systems: Emerging views and practices from the field. In <i>Proceedings of the Hawaii International Conference on Systems Sciences</i> .	404
2	Winter, R., & Strauch, B. (2003): A method for demand-driven information requirements analysis in Data warehousing projects. In <i>Proceedings of the Hawaii International Conference on Systems Sciences</i> .	193
3	Lahrman, G., Marx, F., Winter, R., & Wortmann, F. (2011): Business intelligence maturity: Development and evaluation of a theoretical model. In <i>Proceedings of the Hawaii International Conference on Systems Sciences</i> .	100

6.2 Leximancer Analysis

In this section, we describe the outcomes of our lexical analysis of the minitrack's four main phases. Figures 4 to 7 depict the corresponding Leximancer-generated concept maps that show the key themes and concepts we identified in each phase.

6.2.1 Phase One: 1990 to 1996

As Figure 4 depicts, the first phase demonstrated a strong focus on EIS's organizational aspects. The largest circles correspond to the key themes that papers emphasized at the time, such as "information", "EIS", "system" and "data". Papers placed significantly less emphasis on EIS's technical aspects (which the relatively smaller "bubbles" in less bright colors depict). Similarly, the themes "product" (in this case, the actual EIS software) and "databases" used to store data had less prominence.

We can further see this research's focus on the organization perspective if we look at the key concepts that the papers discussed. For example, the Leximancer-generated thesaurus (not shown here) listed "system", "use", "information", "executive", "management" and "data" as the key themes.

Different connections among the key themes and corresponding concepts offer additional insights into the research in this phase. For example, papers discussed the role of EIS, which included its critical success factors and its design and use. Papers also considered EIS in relation to management information systems (MIS), which we do not find surprising since, at the time, MIS had an established position and EIS had only just begun to emerge. Some papers also focused on databases; however, this type of research did not relate to the main topic EIS.

Finally, case study research that focused on management and executive issues dominated this phase. We performed an additional sentiment analysis, which Leximancer provides as an additional feature, and found that papers reported experiences both positive (i.e., favorable: 51%) and negative (i.e., unfavorable: 49%) experiences with EIS.

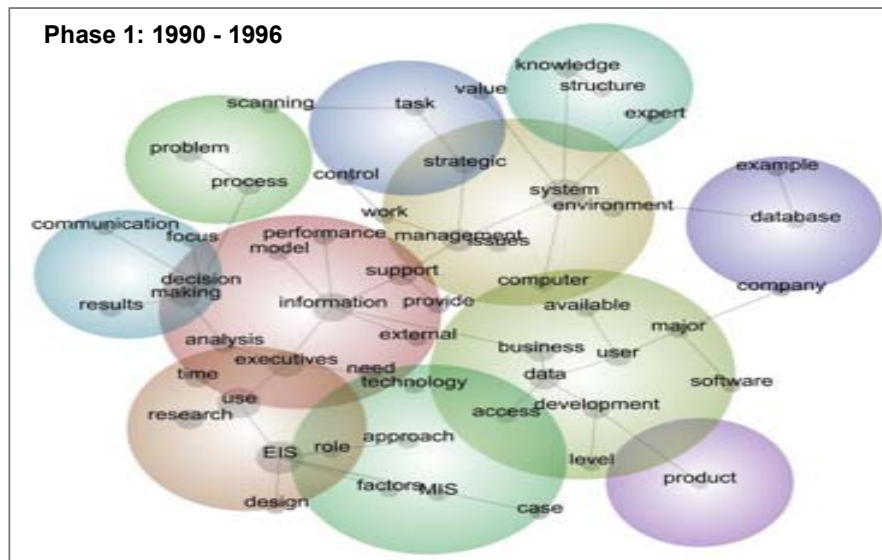


Figure 4. Leximancer Concept Map for Phase One: Executive Information Systems (EIS)

6.2.2 Phase Two: 1997 to 2003

Research in this phase started to focus on DW, which the minitrack's new title reflected. As Figure 5 depicts, a strong emphasis on data dominated this phase. Indeed, the key themes we identified in this phase included "data", "user" and "distributed archives". By examining the underlying raw data and using our domain expertise to reflect on the history of different terms that papers used at the time, we established that "distributed archives" meant "distributed data sources". The corresponding thesaurus offered additional insights into the nature of data-related research in this phase that focused on database systems and listed "data", "system", "user", and "databases" as the key themes.

Various prominent concepts such as "storage", "query", "processing", "access" all point to a very strong emphasis on data warehousing's technical aspects. Although related, the "data warehousing" theme differs from the more prominent and generic theme "data". Papers also strongly emphasized "metadata", though they explored topic mostly in general rather than in relation to data warehousing.

Additional links across key themes and concepts further reinforce the strong technical focus of the research in this phase. For example, Leximancer linked "warehouse" to "query" and "database" but not to "user". When discussing "performance" and "metrics", papers focused on technical performance (i.e., speed) rather than organizational performance.

Figure 5 also indicates that papers emphasized "cases" (i.e., case studies) less. Rather than describing organizational applications of "warehouses", these case studies focused more on database queries and, in particular, on query performance. Interestingly, the cases did not consider the user perspective. Also, papers discussed the organizational aspects to a lesser extent. We can explain these insights based on the fact that case organizations faced challenges in building data warehouses' technical infrastructure.

When considered in a wider context of BI&A research and industry practices, research in this phase echoes the technical focus of data warehousing at the time. For example, Gartner's 2003 "Hype Cycle for Data Warehousing" places "DBMS complex query optimization" and "real-time data updates" at the peak of the hype cycle at the time (Strange & Friedman, 2003).

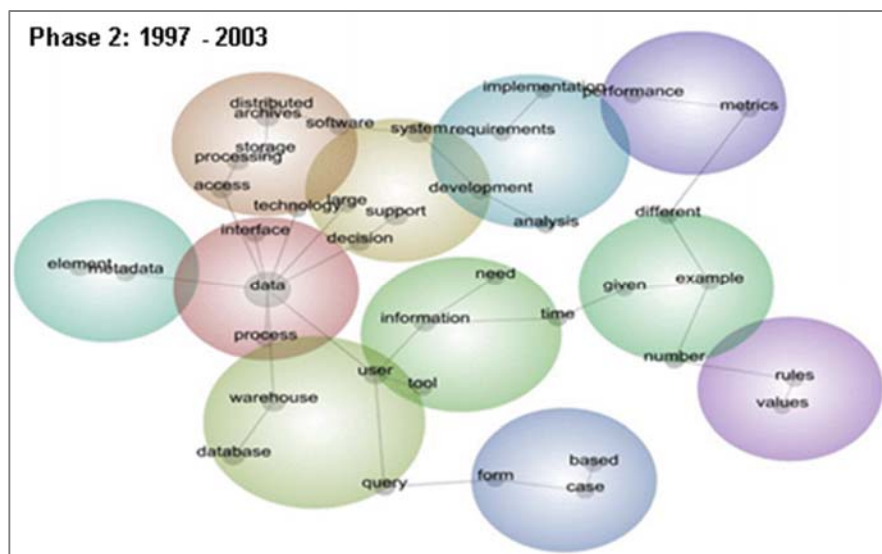


Figure 5. Leximancer Concept Map for Phase Two: Data Warehousing (DW)

6.2.3 Phase Three: 2004 to 2011

The third phase demonstrated a visible shift from databases and DW to information, which included the challenge of turning data into information. Although the term DW remained in the title of the minitrack, it received far less attention. In fact, DW no longer appeared in the concept map and did not appear in the Leximancer-generated thesaurus of the key concepts. Instead, the research in this phase emphasized BI, and the thesaurus listed “information”, “data”, “value”, and “quality” as the key themes.

As Figure 6 shows, the largest and most dense “bubble” indicates that research in this phase strongly focused on various organizational issues. Taken together, the key themes of “value” and “knowledge” point to the new challenges in deriving business value from BI technology.

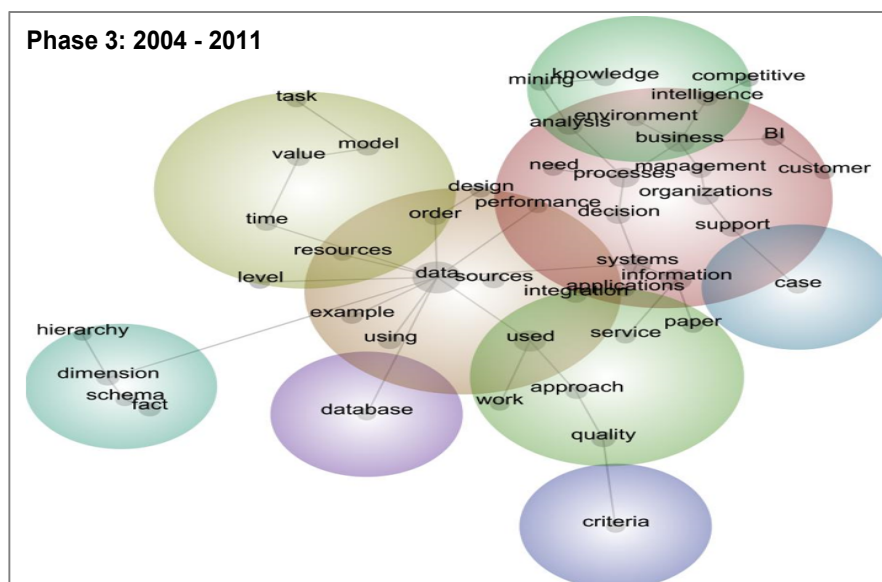


Figure 6. Leximancer Concept Map for Phase Three: DW Extended with BI

In further analyzing the corresponding thesaurus for phase three (not shown here), we found a new key concept, “business process”, that research in the previous two phases did not consider. When interpreted in its historical context, the emergence of “operational BI” during the third phase can explain the increased interest in business processes among BI researchers. This phase also included papers on conceptual modeling, which the theme “dimension” indicates. In addition to data modeling, researchers also focused on data integration and data quality. Although still prominent, papers discussed the topic “databases” to a lesser extent and in isolation from the other key themes.

6.2.4 Phase Four: 2012 to 2017

The fourth phase represents the most recent phase of the minitrack, which introduced the “big data” concept in 2013. As Figure 7 depicts, this phase included a wide variety of themes and concepts. Indeed, a larger and wider concept map (compared to the previous phases) reflects this conceptual diversity. BI remained one of the key themes that papers in this phase discussed (which the largest and brightest “bubble” depicts). However, through deeper analysis, we found surprisingly diverse interpretations of BI (e.g., DW technology, reporting tools, decision support). Research continued to discuss business processes but to a lesser extent than in the third phase. The concept of agility and agile BI appeared for the first time. When considered in its wider historical context, the emergence of real-time DW and BI during earlier years of the fourth phase may explain this interest in agile BI.

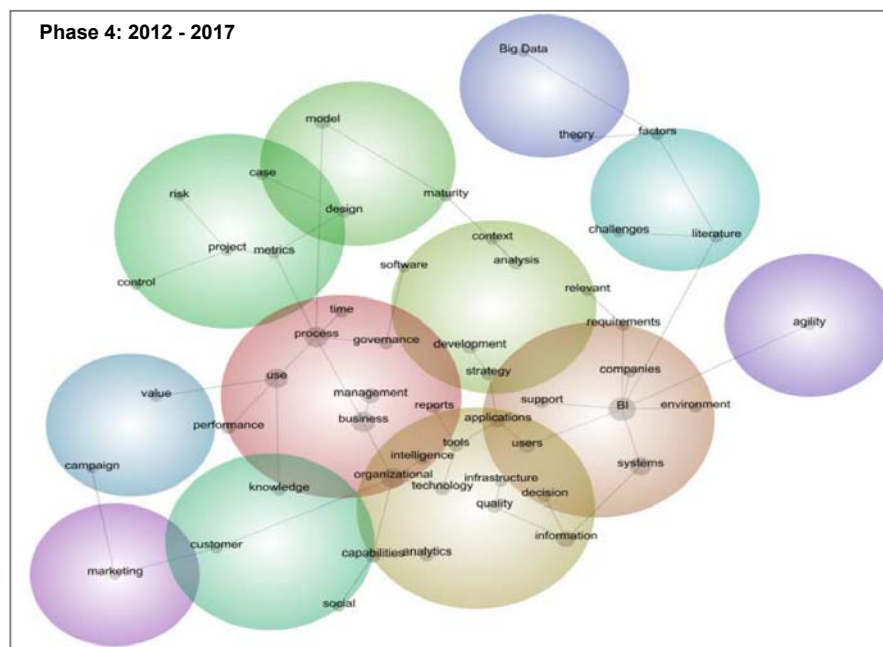


Figure 7. Leximancer Concept Map for Phase Four: BI Extended with BA (2012) and Big Data (2013)

Even though big data appeared as one of the themes that Leximancer identified, it did not represent the most prominent one. Research used the “big data” concept in relation to “theory”, which may have occurred due to the need to build new theoretical foundations for this emerging phenomenon. Compared to all other phases, the fourth phase also included more literature review papers (primarily related to big data).

To learn more about the emerging research on big data, we performed further analysis as Figure 8 depicts. As the figure shows, Leximancer linked “big data” to “strategy”, “value”, and other organizational/business concepts rather than technology infrastructure. Papers that discussed practical applications of big data did so only in relation to marketing and, more specifically, to campaign management.



Table 4 summarizes the key themes, concepts and insights we found in each phase. Looking across all four phases, we can observe common themes such as “data” and “information” that remain relevant regardless of what types of data papers investigated. This particular observation puts the current “big data hype” in its historical context and invites researchers to re-examine the key frameworks and theories from DSS and other predecessor research disciplines. By revisiting these long-established frameworks, such as Ralph Sprague’s framework for developing decision support systems as Watson (2018) demonstrates, we may discover “a way of looking at and understanding current developments in business intelligence and analytics (BI/A)” (p. 364).

This minitrack continues to emphasize that organizational and societal contexts do matter. In fact, one needs to understand such contexts to more deeply understand existing and emerging organizational issues. In Section 7, we reflect on the adopted research method and its outcomes, which includes the role of semantic text-mining technology in our research.

Table 4. Key Concepts and Themes Observed Across Different Phases

Minitrack phase	Key themes and their relevance (10% or above)	Key concepts (extract)	Key insights
1990-1996	Information (100%) EIS (66%) System (53%) Data (50%) Problem (18%) Approach (14%) Knowledge (10%)	System Use Information Executives Management Data	<ul style="list-style-type: none"> • Strong focus on business/organizational aspects and applications of EIS rather than technology • Sentiment analysis: both positive (i.e., favorable: 51%) and negative (unfavorable: 49%) experiences with EIS reported.
1997-2003	Data (100%) Distributed (94%) System (82%) User (71%) Information (41%) Metadata (20%) Analysis (15%) Case (14%)	Data System User Database Warehouse Support Query	<ul style="list-style-type: none"> • Strong focus on technical aspects of DW • Prominent concepts such as “database” and “query” related to data storage and processing • Key themes: performance related issues, metrics, and metadata • Prominence of case studies
2004-2011	Information (100%) Data (73%) Value (25%) Quality (24%) Knowledge (19%) Dimension (15%)	Data Use Information Business Process System	<ul style="list-style-type: none"> • A very visible shift from data bases and DW to information (including the challenges of turning data into information) • Key themes “value” and “knowledge” indicated challenges in deriving business value of BI technology and turning insights into knowledge • Prominence of conceptual modeling papers and data quality (to a lesser extent)
2012-2017	Data (100%) Business (95%) Information (94%) BI (62%) Model (27%) Value (13%) Customer (12%)	Data Use Process Systems Information Model Management Analysis	<ul style="list-style-type: none"> • BI remained among the key themes but interpretations became quite diverse • Although present on the concept map, “big data” did not appear among the most prominent concepts and themes • The “big data” concept related to “theory” because researches had concerns about the lack of theoretical foundations of big data and focused on building new (big data) theories • This phase included more literature review papers than any other phase (primarily in relation to big data)

7 Reflections on the Research Method and its Outcomes

BI&A's highly dynamic nature makes literature reviews an important component of our disciplinary discourse. Our method of using a lexical data-analysis tool extends the current approaches to BI&A literature review beyond the more prominent thematic analyses, systematic literature reviews, and citation analyses. Rather than just focusing on papers and their analysis, we also consider the identified key concepts and themes in their relevant historical context of BI&A research and industry practices over the four research phases.

Due to the versatile ways in which researchers have applied Leximancer, some have described Leximancer as a “text-mining tool for visualizing the structure of concepts and themes in text” (Anagnostopoulos & Bason, 2015, p. 25), a visual tool for making sense of big data (Angus, Rintel, & Wiles, 2013), a data-mining tool (Shollo & Kautz, 2010), a tool for analyzing qualitative data (Crofts & Bisman, 2010) or quantitative content (Lock & Seele, 2015), and a quantitative tool for qualitatively analyzing text data (Indulska et al., 2012).

Based on our experience in this research, we see our study in which we used Leximancer to examine research as a computer-supported qualitative study. In this study, we conducted an iterative, reflective,

and human-driven sensemaking process via which meaning gradually emerged. This particular view challenges the common assumption that one can automatically derive “meaning” with any text-mining tool, including Leximancer.

Consequently and in reflection, we can best describe our research method as a form of a technology-supported but human-driven sequence of hermeneutic circles (Crotty, 1998; Gadamer, 1960; Klein & Myers, 1999) because our understanding constantly moved from the “whole” (the minitrack history, its phases, and the wider history of BI&A research and industry practice) to the “parts” (thematic visualizations and corresponding raw text) and back to the whole.

While the technology makes the mechanics of the text-mining process replicable and scalable, in our view, human interpretation by domain experts makes it meaningful and contextual. Researchers interested in using Leximancer (or similar tools) in their own contexts and domains should consider this point because technology does not generate meaning but rather individuals do in context.

Our method of using Leximancer provides future research opportunities, especially in relation to the emerging BI&A research topics and their treatment at different relevant conferences. For example, it would be interesting to analyze the content of all big data-related papers that different minitracks at this conference and other prominent IS conferences have published. Doing so could provide researchers with additional insights into the focus and “flavor” of a particular conference or minitrack so they could make important decisions about where to send their work in the future.

8 Conclusions and Future Work

We decided to conduct the research we report in this paper with inspiration from the 50th anniversary of HICSS. We trace and analyze the 28-year history of relevant and interesting research discussed in the BI&A minitrack at HICSS currently called organizational issues of business intelligence, business analytics, and big data. We also demonstrate a method of using an advanced BI&A tool for semantic text mining to illustrate our own “tool of the trade” in our research context.

While other researchers have comprehensively reviewed BI&A and big data literature and we can expect such reviews to continue, we focus on a single conference minitrack and analyze different phases of its history. Our analysis confirms that the minitrack’s evolving progress from EIS, DW, BI, BA, and, most recently, big data has fully aligned with industry trends. Researchers cannot easily achieve this important alignment given the very dynamic nature of the BI&A discipline and the ongoing challenges it continues to create in terms of the required reviews and publication cycles. Our research also confirms the truly international nature of this minitrack that has grown from its USA-based origins to also include papers from Europe, Australia, Asia/Pacific, and Africa.

The more recent history of HICSS has seen it introduce other minitracks related to BI&A (as we define it in our paper) and new topics such as the Internet of things (IoT), open data, datafication, and so on. As our data set remains limited to only one minitrack, one should not view our findings as representing all BI&A papers that HICSS has published. However, being the longest running BI&A-related minitrack at this conference, it has certainly contributed to establishing HICSS as the leading international conference for BI&A research (Chen et al., 2012). In our future work, we plan to include citation and social network analyses of minitrack contributions, research collaborations, and the collective influence that BI&A researchers continue to make in and beyond this highly influential conference.

The BI&A discipline continues to evolve and change. For example, artificial intelligence, cognitive computing, and IoT data have begun to create new challenges for BI&A research. These challenges will continue to take this minitrack in new and exciting directions.

Finally, we need to learn from our collective past because, from doing so, we can better understand the origins of our current thinking. However, we cannot predict future-oriented thinking and new practices by looking in a “rear view mirror” and analyzing the past as we do in this research. In contrast, only a vibrant community of researchers and practitioners who continue to share their ideas at HICSS for many years to come can do so.

References

- Abbasi, A., Sarker, S., & Chiang, R. H. L. (2016). Big data research in information systems: Toward an inclusive research agenda. *Journal of the Association of Information Systems*, 17(2), 1-32.
- Anagnostopoulos, C., & Bason, T. (2015). Mapping the first 10 years with Leximancer: Themes and concepts in the sports management. *International Journal Choregia*, 11(1), 25-41.
- Angus, D., Rintel, S., & Wiles, J. (2013). Making sense of big text: A visual-first approach for analysing text data using Leximancer and Discursis. *International Journal of Social Research Methodology*, 16(3), 261-267.
- Arnott, D., & Pervan, G. (2005). A critical analysis of decision support systems research. *Journal of Information Technology*, 20(2), 67-87.
- Aryal, A., Gallivan, M., & Tao, Y. (2015). Using latent semantic analysis to identify themes in IS healthcare research. In *Proceedings of the 21th Americas Conference on Information Systems*.
- Baars, H., Felden, C., Gluchowski, P., Hilbert, A., Kemper, H. G., & Olbrich, S. (2014). Shaping the next incarnation of Business intelligence: Towards a flexibly governed network of information integration and analysis capabilities. *Business and Information Systems Engineering*, 6(1), 11-16.
- Carter, M., Petter, S., & Randolph, A. B. (2015). Desperately seeking information in information systems research. In *Proceedings of the 36th International Conference on Information Systems*.
- Chee, T., Chan, L.-K., Chuah, M.-H., Tan, C.-S., Wong, S.-F., & Yeoh, W. (2009). Business intelligence systems: State-of-the-art review and contemporary Applications. In *Proceedings of the Symposium on Progress in Information and Communication Technology* (pp. 96-101).
- Chen, C. L. P., & Zhang, C.-Y. (2014). Data-intensive applications, challenges, techniques and technologies: A survey on big data. *Information Sciences*, 275, 314-347.
- Chen, H., Chiang, R. H. L., & Storey, V. C. (2012). Business intelligence and analytics: From big data to big impact. *MIS Quarterly*, 36(4), 1165-1188.
- Cretchley, J., Rooney, D., & Gallois, C. (2010). Mapping a 40-year history with Leximancer: Themes and concepts in the Journal of Cross-Cultural Psychology. *Journal of Cross-Cultural Psychology*, 41(3), 318-328.
- Crofts, K., & Bisman, J. (2010). Interrogating accountability: An illustration of the use of Leximancer software for qualitative data analysis. *Qualitative Research in Accounting and Management*, 7(2), 180-207.
- Crotty, M. (1998). *The foundations of social research: Meaning and perspective in the research process*. St. Leonards: Allen & Unwin.
- Gadamer, H.-G. (1960). *Truth and method*. New York, NY: Continuum.
- Goul, M. (2010). Business intelligence at the crossroads: Convergence or confusion ahead? In *Proceedings of the International Conference on Information Technology Interfaces* (pp. 21-28).
- Gupta, B., Goul, M., & Dinter, B. (2015). Business intelligence and big data in higher education: Status of a multi-year model curriculum development effort for business school undergraduates, MS graduates, and MBAs. *Communications of the Association for Information Systems*, 36, 449-476.
- Hashem, I. A. T., Yaqoob, I., Badrul Anuar, N., Mokhtar, S., Gani, A., & Ullah Khan, S. (2015). The rise of "big data" on cloud computing: Review and open research issues. *Information Systems*, 47, 98-115.
- Hosack, B., Hall, D., Paradise, D., & Courtney, J. F. (2012). A look toward the future: Decision support systems research is alive and well. *Journal of the Association for Information Systems*, 13(5), 315-340.
- Indulska, M., Hovorka, D. S., & Recker, J. (2012). Quantitative approaches to content analysis: Identifying conceptual drift across publication outlets. *European Journal of Information Systems*, 21(1), 49-69.
- Indulska, M., & Recker, J. C. (2008). Design science in IS research: A literature analysis. In G. Shirley & S. Ho (Eds.), In *Proceedings of the 4th Biennial ANU Workshop on Information Systems Foundations*.

- Jourdan, Z., Kelly Rainer, R., & Marshall, T. E. (2008). Business intelligence: An analysis of the literature. *Information Systems Management*, 25(2), 121-131.
- Kambatla, K., Kollias, G., Kumar, V., & Grama, A. (2014). Trends in big data analytics. *Journal of Parallel and Distributed Computing*, 74(7), 2561-2573.
- Klein, H. K., & Myers, M. D. (1999). A set of principles for conducting and evaluating interpretive field studies in information systems. *MIS Quarterly*, 23(1), 67-94.
- Leximancer. (2010). *Leximancer white paper*. Retrieved from https://www.leximancer.com/lmedia/Leximancer_White_Paper_2010.pdf
- Lock, I., & Seele, P. (2015). Quantitative content analysis as a method for business ethics research. *Business Ethics: A European Review*, 24(S1), S24-S40.
- Mayhew, H., Saleh, T., & Williams, S. (2016). Making data analytics work for you—instead of the other way around. *McKinsey Quarterly*. Retrieved from <http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/>
- Negash, S. (2004). Business intelligence. *Communications of the Association for Information Systems*, 13, 177-195.
- Phillips-Wren, G., Iyer, L. S., Kulkarni, U., & Ariyachandra, T. (2015). Business analytics in the context of big data: A roadmap for research. *Communications of the Association for Information Systems*, 37, 448-472.
- Pirttimäki, V. H. (2007). Conceptual analysis of business intelligence. *South African Journal of Information Management*, 9(2), 1-17.
- Power, D. J. (2007). A brief history of decision support systems. *DSSResources.com*. Retrieved from <http://dssresources.com/history/dsshistoryv28.html>
- Shollo, A., & Kautz, K. (2010). Towards an understanding of business intelligence. In *Proceedings of the 21st Australasian Conference on Information Systems*.
- Smith, A. E., & Humphreys, M. S. (2006). Evaluation of unsupervised semantic mapping of natural language with Leximancer concept mapping. *Behavior Research Methods*, 38(2), 262-279.
- Strange, K. H., & Friedman, T. (2003). Hype cycle for data warehousing, 2013. *Gartner*. Retrieved from <https://www.bus.umich.edu/KresgePublic/Journals/Gartner/research/115100/115194/115194.pdf>
- Veeramachaneni, K. (2016). Why you're not getting value from your data science. *Harvard Business Review*, 12, 1-4.
- Watson, H. J. (2018). Revisiting Ralph Sprague's framework for developing decision support systems. *Communications of the Association for Information Systems*, 42, 363-385.
- Watson, H. J. (2014). Tutorial: Big data analytics: Concepts, technologies, and applications. *Communications of the Association for Information Systems*, 34, 1247-1268.
- Watson, H. J. (2009). Tutorial: Business intelligence—past, present, and future. *Communications of the Association for Information Systems*, 25, 487-510.
- Watson, H. J., & Marjanovic, O. (2014). Big data: The fourth data management generation. *Business Intelligence Journal*, 18(3), 4-7.
- Young, L., Wilkinson, I., & Smith, A. (2015). A scientometric analysis of publications in the Journal of Business-to-Business Marketing 1993-2014. *Journal of Business-to-Business Marketing*, 22(1-2), 111-123.

About the Authors

Olivera Marjanovic is a Professor of Contemporary Technology Leadership at University of Technology Sydney, Australia. She holds a PhD from the University of Queensland, Australia. Her research interests include qualitative and action design studies of organisational and societal aspects of business intelligence, business analytics and big data, datafication effects, data humanism, algorithmic justice, data visualisation and data-driven visual storytelling. She is particularly interested in human-centric applications of advanced analytics and algorithmic decision making in transformative services and other complex human systems. She currently leads a large-scale action design research project funded by the Australian Research Council Discovery Project that includes implementation of a first-of-its kind industry-wide interactive visual data exploration environment called Visual Atlas of the Australian Cooperatives. Olivera has published over 150 journal and conference publications in business intelligence and analytics, business process management, knowledge management and innovative education.

Barbara Dinter is a Professor of Business Information Systems at Chemnitz University of Technology, Germany. She holds a PhD from the Technische Universität Muenchen, Germany, where she previously earned a master's degree in computer science. Barbara worked for several years at University of St. Gallen, Switzerland as a Post-Doc and project manager. In her role as an IT consultant, she worked with a variety of organizations. Her research interests include business intelligence and analytics, big data, data driven innovation, and information management. She has published in renowned journals such as *Decision Support Systems*, *Journal of Database Management*, and *Journal of Decision Systems* and has presented her work on conferences such as ICIS, ECIS, and HICSS. In addition, she has served as a track chair or associate editor for numerous international conferences and as a guest editor in journals.

Copyright © 2018 by the Association for Information Systems. Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and full citation on the first page. Copyright for components of this work owned by others than the Association for Information Systems must be honored. Abstracting with credit is permitted. To copy otherwise, to republish, to post on servers, or to redistribute to lists requires prior specific permission and/or fee. Request permission to publish from: AIS Administrative Office, P.O. Box 2712 Atlanta, GA, 30301-2712 Attn: Reprints or via e-mail from publications@aisnet.org.